

1. Introduction

Informal Working Group 4 (IWG-4) of the FCC Industry Advisory Committee for WRC-95 is tasked with developing U.S. industry consensus positions on proposals for preferred FSS frequency bands which could support MSS feeder link spectrum. As such, the IWG has been considering a number of issues related to the provision of MSS feeder link spectrum. This interim report represents the current views of IWG-4 on this topic and work shall continue through the early part of 1995 in order to resolve all outstanding issues.

IWG-4 has met six times to date, and was well attended on all occasions by U.S. industry and government participants (See Attachment 1 for IWG-4 Participants List). It should be noted that many of the participants in IWG-4 were also very actively involved in a similar international effort on this same topic coordinated by the International Telecommunications Union (i.e. ITU-R Task Group 4/5). Task Group 4/5 was responsible for developing the technical basis for MSS feeder link use of various FSS bands and this Task Group has recently completed its work and will be submitting a report to the Conference Preparatory Meeting.

While there were times where this cross participation in IWG-4 and Task Group 4/5 resulted in scheduling conflicts, in general IWG-4 has benefited greatly from this fact. Much of the work done in preparation for, and during, the international meetings of Task Group 4/5 was directly applicable to the work of IWG-4. In fact, much of the content of this Interim Report has already been vetted internationally and this will no doubt serve to further its acceptance at WRC-95.

This Interim Report contains reasonably stable text pertaining to the Overall Spectrum Requirements for MSS Feeder Links (Section 2), the Considerations Relating to the Choice of Frequency Bands (Section 3) and Feasibility of Frequency Sharing Between MSS Feeder Links and Other Services (section 4). In the area of Regulatory and Procedural Issues (Section 5), much of the text recently agreed by ITU-R Task Group 4/5 has been included in this Interim Report. While IWG-4 participants were actively involved in the development of this text, and endorse it, there may be some areas still requiring the specific attention of the IWG. Finally, specific U.S. Proposals for MSS Feeder Link Bands have yet to be developed, however, as can be seen in Section 6 of this Interim Report, IWG-4 has been able to narrow the scope of this topic and shall be considering a specific set of frequency bands in its further work.

Attachment 2 to this Interim Report contains a listing of the IWG-4 documents considered which led up to this Interim Report.

2. Overall Spectrum Requirements for MSS Feeder Links

2.1 The Need for Sufficient Spectrum

Geostationary MSS systems, in general, can utilize FSS allocations for feeder links in a co-directional mode with FSS operations. Thus, Geostationary MSS systems may not require the identification of specific frequency bands for feeder links. However, additional challenges are involved in identifying suitable frequency bands for non-Geostationary MSS systems. As a first step in this process, it is necessary to quantify the amount of spectrum that is required for first generation non-Geostationary (NGSO) MSS systems. These systems propose to use the bands 1610-1626.5 MHz and 2483.5-2500 MHz for service links.

A number of NGSO MSS systems are currently planned for implementation and it is useful to focus on the feeder-link spectrum requirements for these systems. Feeder link requirements for future non-GSO MSS systems should also be considered however, as the feeder link allocations for currently planned systems may not be adequate to accommodate future systems. Depending on system characteristics, NGSO MSS systems propose to use varying amounts of feeder link bandwidths in the frequency range from 4-31 GHz.

Estimating the bandwidth needs for NGSO MSS feeder links is not the same as estimating the bandwidth needs for GSO systems, although some factors are similar. The factors which need to be taken into account include: (1) the amount of spectrum in the service link, (2) the number of the reuses of this spectrum, (3) the system design concept, (4) the frequency band of operation, and (5) the coordination flexibility/shareability of spectrum with other systems.

NGSO MSS operators have indicated clear preferences for frequency bands for accommodation of NGSO MSS feeder-links, based on service and system design objectives. Use of frequency bands below 16 GHz may possibly enable systems to employ dual polarization, thus substantially reducing feeder link spectrum requirements.

Consequently, in estimating spectrum requirements for systems proposing feeder links below 16 GHz, use of dual polarization has been assumed. Such an assumption cannot be made for feeder link spectrum above 16 GHz.

The feasibility of multiple systems sharing the same feeder link spectrum continues to be evaluated. Geometric and computer analysis verify that in-line interference will occur when multiple systems use the same feeder link spectrum. However, a variety of techniques, coordinated by the systems, may be available to reduce the frequency of occurrence and duration of in-line interference events to acceptable values. Because the feasibility of multiple systems sharing the same feeder link spectrum has not been fully established, feeder link spectrum requirements under both the assumption that sharing is feasible and the assumption that sharing is not feasible have been developed.

2.2 First Generation Vs Second Generation Feeder Links Requirements

Feeder link spectrum requirements for a given system can be roughly estimated using system parameters such as service link bandwidth, frequency reuse factor in service link, number of spot beams per satellite, polarization reuse factor in feeder link and guard band factor. Due to differences in these parameters in each of the many proposed NGSO MSS systems, varying amounts of feeder link spectrum in the 4-31 GHz range are required to support each system. The following chart identifies the feeder link bandwidth requirements under the assumption that sharing is feasible, and under the assumption that sharing is not feasible.

**Current Estimates for Feeder Link Requirements
for First Generation NGSO MSS Systems
Operating Service Links in the 1-3 GHz Band**

Frequency Range	Spectrum (each direction) Sharing Possible**	Spectrum (each direction) No Sharing
4-8 GHz	200 MHz	400 MHz
8-16 GHz	200 MHz	400 MHz
16-30 GHz	250 MHz***	500 MHz***

** Assuming sharing of feeder link spectrum by multiple NGSO MSS systems

*** Use of dual polarization is not feasible

While development of estimated requirements for currently identified systems provides a baseline for feederlink allocation proposals, revisions to the International Table of Allocations which would permit operation of NGSO MSS feeder links in a wide range of frequency bands would be beneficial.

With regard to feeder link spectrum requirements for future NGSO MSS systems, it is difficult at this time to develop fully accurate projections. Space segment design, system architecture, service requirements and the use of techniques such as digital processing can influence these requirements. Such requirements would not necessarily be directly additive to those for the systems currently planned.

3. Considerations Relating to Choice of Frequency Bands for MSS Feeder Links

3.1 Possible Impact on System Design, Operation and Cost

The optimum choice of MSS feeder link frequency band depends upon the particular MSS system characteristics. Because of this fact, and the difference in system characteristics between the various U.S. MSS proponents, it is desirable to obtain allocations for MSS feeder links in several different parts of the spectrum in order to maximize flexibility and the scope for technical innovation in providing MSS to the public.

Although two of the U.S. MSS proponents have expressed the desire to utilize frequencies in the 20/30 GHz range (Ka-Band) for feeder links, others have proposed frequencies in lower bands. The following discussion offers a rationale for MSS feeder link provisions in three established FSS frequency ranges.

4-8 GHz (C-Band):

One of the driving factors for the utilization of frequencies between 4-8 GHz (C-Band), despite its heavy use by the FSS, is the desire to design a system that uses global (or near global) coverage feeder link antenna beams. With only one (or a few) feeder link beam(s), a feeder link Earth Station (ES) can be located anywhere in the beam. This gives the MSS operator and host countries a great deal of flexibility in locating and siting

feeder links ES's. This is an important consideration in a system where the exact locations and numbers of the feeder link ES's are unknown at the design stage.

Additionally, systems using these frequencies can use well developed technology in a band where propagation impairments do not result in significant cost impact. The resulting need for relatively small link margins can be exploited through the use of relatively low cost feeder link ES's.

8-17.7 GHz (Ku-Band):

One of the advantages of this range of frequencies is that it contains a virtually unused 500 MHz portion of spectrum that is currently included in the WARC-88 Allotment Plan allocations. There are also a number of other FSS bands available at Ku-Band, although coordination with VSAT's, TVRO's, and BSS feeder links may make implementation of MSS feeder links difficult. The desire to avoid the rain fading and site-diversity problems that are inherent at Ka-band also make this band attractive.

20-30 GHz (Ka-Band):

Among the reasons for choosing this part of the spectrum are that at present it is relatively lightly used, relatively easy to coordinate, and contains a significant bandwidth allocation. In addition, the utilization of narrower feeder link beams on the satellite, without recourse to large satellite reflectors, provides the additional link gain required to overcome rain fade effects. Finally, in system designs which provide for flexibility in the location of feeder link earth stations, due to either increased orbit altitude or the use of inter-satellite links, it is possible to locate feeder link stations in areas of low rainfall, thereby avoiding some of the rain attenuation problems normally associated with this frequency band.

3.2 Co-Directional vs. Reverse Direction Use of FSS Bands

Co-Directional Use

In principle, any frequency band allocated to the FSS may be used co-directionally by MSS feeder links without modifications to the Table of Frequency Allocations. In practice, however, it is clear that not all FSS bands are attractive for

NGSO MSS feeder link use. Co-directional sharing would result in in-line coupling configurations between GSO FSS and NGSO MSS systems. The magnitude and resultant impact of these in-line configurations is dependent upon the frequency band of operation. In general, in-line coupling, and its resultant interference, is less severe and hence more manageable at Ka-Band than it is at either C or Ku-band. This topic is further discussed in Section 4.1.

Reverse Band Working

The Reverse Band Working (RBW) concept involves the operation of an MSS feeder link in the opposite direction from the FSS allocation. The use of RBW eliminates "in-line" coupling events but introduces the possibility of satellite-to-satellite and ground station-to-ground station interference. This will be discussed further in Section 4.2 of this report. The use of RBW also introduces additional cost to the MSS systems. The transposing of receive and transmit frequency bands, relative to current practice, means that new hardware developments would be required for operation in the required frequency bands. This consideration is particularly important at the higher frequencies, and in fact renders RBW much less attractive at Ka-Band.

4. Feasibility of Sharing Between NGSO MSS Feeder Links and Other Services and Between Multiple NGSO MSS Feeder Links Systems

4.1 Co-Directional Frequency Sharing Between NGSO MSS Feeder Links and GSO FSS Systems

As discussed previously, when NGSO MSS feeder links and GSO FSS links share the same frequency band co-directionally, in-line coupling can occur. This in-line coupling can result in high levels of short term interference and internationally, short-term interference criteria have been adopted for this case. Through extensive computer simulations of this problem it has been determined that the percentages of time for which short-term interference thresholds would be exceeded would be far greater than is likely to be acceptable for most GSO FSS and NGSO MSS carriers in C and Ku-Band. In addition, the level of operational constraint which would be required in order to meet the short term interference criteria would also be considered unacceptable. Because of this fact, IWG-4 believes that co-directional sharing in the C and Ku-Bands bands occupied by large numbers of GSO FSS systems is not practicable.

The computer simulations mentioned above however have also shown that the in-line interference situation is less severe at Ka-Band. Hence, through the use of interference reduction mechanisms, IWG-4 believes that co-directional sharing may be possible at 20 and 30 GHz.

4.2 Reverse Direction Frequency Sharing Between NGSO MSS Feeder Links and GSO FSS Systems

Work in international forums has shown that sharing between NGSO MSS feeder links in RBW and GSO FSS systems in the forward band mode is technically feasible in the C and Ku-Bands, including the Allotment Plan bands (i.e. 4500-4800/6725-7025 MHz and 11.20-11.45/12.75-13.25 GHz). This work has also shown this type of operation to be technically feasible in the Ka-Band, however, there are severe practical constraints associated with this type of operation at Ka-Band. The results of analyses indicate that:

- Sharing of NGSO MSS feeder links in RBW mode in the C and Ku-Band FSS allocations is feasible,
- The satellite-to-satellite interference, in both directions, is well within acceptable interference criteria,
- For earth station-to-earth station interference, the coordination distances range from 100 to 300 km in C-Band and 100 to 225 km in Ku-Band and can be further reduced by site shielding,
- From practical considerations of maintaining system costs within reasonable bounds and of minimizing operational constraints on both GSO FSS and NGSO MSS systems, RBW is not preferred in Ka-band and in congested FSS bands such as those where there exist a large number of earth stations authorized without any requirements for coordination.

Considering all of this, IWG4 fully endorses the use of RBW in the lightly used FSS bands below 17.7 GHz, recognizing the need for allocation and regulatory decisions at the WRC-95. RBW is an important technique because it provides the NGSO MSS operators with a method for using the FSS bands for feeder links without resulting in unacceptable interference to either GSO FSS networks or NGSO MSS feeder links.

4.3 Frequency Sharing Between NGSO MSS Feeder Links and Fixed Service Networks

4.3.1 Interference from NGSO MSS Satellite Feeder Link into Fixed Service Station

Studies of interference from NGSO MSS satellite feeder links into FS stations have shown that sharing is feasible. Some concerns, however, have been expressed as to whether the limits in Article 28 could really be applicable to NGSO satellites. The rationale behind this was that even if the PFD limits in Article 28 are met, in-line interference could exceed the maximum C/I criterion for short periods of time. A set of PFD limits applicable to NGSO MSS feeder-link satellites shall, therefore, be proposed in the Final Report of IWG-4.

The interest of RBW was certainly sharpened through Recommendation SF 1005 in which it is suggested that below 10 GHz RBW is not feasible because of heavy usage by the FSS, and above 10 GHz PFD limits have to be tightened. Even though Recommendation 1005 had addressed bands above 10 GHz only, for bi-directional usage by GSO FSS, it may be possible to identify bands which are lightly occupied by FS, to accommodate NGSO MSS feeder links. A set of PFD limits applicable to NGSO MSS feeder link satellites shall be proposed for bands that are shared bi-directionally with GSO FSS in the Final Report of IWG-4.

4.3.2 Interference from Fixed Service Station into NGSO MSS Satellite Feeder Link

The worst case aggregate interference, from multiple FS transmitters into NGSO MSS satellite feeder uplinks is well within the protection criteria. Concerns have been expressed, however, on the possible interference from trans-horizon systems in the band 4500 - 4 800 MHz. The very high transmit power of these systems (in the order of several KW) could make the use of parts of this band almost impossible for NGSO MSS satellites.

4.3.3 Interference Between NGSO MSS Feeder Link Earth Station and Fixed Service Station

Application of Recommendation IS.847 and Recommendation IS.849 can be directly applied to sharing between NGSO MSS earth stations and FS stations. It has been shown that sharing feasibility between NGSO MSS earth stations and FS stations is of the same magnitude as between FSS and FS.

Concerns have been expressed, however, on the number of NGSO MSS feeder-link earth stations, the use of RBW and the number of FS stations. In the first instance, a high density of MSS feeder-link earth stations would certainly make the sharing difficult. However, most of the actual systems proposed today have a range of 25 to 200 stations worldwide (up to 15 stations for one system operating on the contiguous United States). It must also be pointed out that it is expected that different systems will operate in different bands, thereby further limiting the total number of earth stations operating in any given frequency band.

4.3.4 Reverse Band Working of NGSO MSS Feeder Links and the FS

It is recognized that if RBW mode is recommended in bands that are not heavily used by FSS, this usage is not expected to suffer from the constraint of another existing interference mode. However, it is noted that in Recommendation SF.1005 RBW was not considered below 10 GHz because of its inapplicability in bands heavily occupied by the FS. This certainly needs to be clarified, as several MSS systems are considering reverse band operation below 10 GHz in bands that may not be heavily used by FS. It is then expected that, notwithstanding the existence of Recommendation 1005, RBW to NGSO MSS feeder links in the bands lightly used by FSS may not need to be additionally constrained.

4.4 Frequency Sharing Between NGSO MSS Feeder Links and the Aeronautical Radionavigation Service (ARNS) in the 5000-5250 MHz Band

4.4.1 Sharing between NGSO MSS feeder links and MLS

The band 5000-5250 MHz is allocated to ARNS. The Microwave Landing System (MLS), as developed in accordance with ICAO standards, has precedence over all other uses of this band (RR 796). RR 953 states that the safety aspects of radionavigation require special measures to ensure their freedom from harmful

interference. There is a strong interest in using this band or part of this band for MSS feeder-links.

In the uplink direction, preliminary studies have shown that co-frequency sharing between MLS and NGSO MSS feeder link earth stations may be technically feasible with a minimum coordination distance at least 400 km from MLS sites, assuming similar altitudes of the MLS and MSS sites.

Recognizing the critical safety aspects of MLS, it is recommended that NGSO MSS feeder-links and MLS use non-overlapping spectrum. MLS use coordinated by ICAO currently occupies the band 5030-5091 MHz and in the future is planned to occupy 5030-5150 MHz. In principle, MLS may be reorganized in the future in the band 5000-5120 MHz. ICAO has indicated that such reorganization could be given favourable consideration. Accommodating MLS in the band 5000-5120 MHz would then yield 130 MHz of contiguous spectrum for NGSO MSS feeder links that would not overlap MLS in frequency. It is estimated that use of the band not overlapping MLS channels results in restricting MSS feeder link earth stations from operating within about 50 km from each MLS site.

Prior to the future need of additional channels for MLS as identified by ICAO, it may be feasible for MSS feeder-links to use the band 5000-5030 MHz and 5091-5150 MHz if an appropriate regulatory procedure is adopted by a WRC to accommodate MLS expansion into this portion of the band if and when MLS requires additional channels in this band.

Sharing within the MLS-channelled band, although technically feasible, would require coordination on a case by case basis with great care to ensure the integrity of MLS. In-band sharing will require either (1) operation beyond radio horizon; or (2) terrain blocking along with other possible mitigation techniques that offer high integrity (i.e. consistent with the requirements of MLS). Among these techniques, terrain blocking will play a special role as being a technique that is not subject to failure or human error. Active monitoring and automatic feeder link transmitter shutdown, in the case of monitoring threshold exceedance, will most likely be required to ensure MLS integrity under all conditions. Theoretical analyses must be augmented by practical tests before these techniques can be endorsed. Further studies are required before any conclusions can be made. In all cases, the requirements of MLS will take precedence in the band.

In the downlink direction, sharing with NGSO MSS feeder links would be feasible if Non-GSO/MSS satellite emissions are constrained by an appropriate PFD limit at the MLS equipped aircraft.

It should be noted that the MLS interference threshold should not be exceeded by the aggregate of all relevant signals, including uplink and downlink feeder links which share the band.

4.4.2 Sharing between NGSO MSS feeder links and other services

Other aeronautical services have been identified in the band 5000-5250 MHz that may require protection from NGSO MSS feeder link emissions. No study has been made so far to assess the feasibility of sharing those other services with NGSO MSS feeder links.

Non-ICAO MLS systems are mainly used for landing naval aircraft on land and ships. The level of protection required for such a system is expected to be less stringent than for the ICAO standard MLS but is yet to be determined. A Non-ICAO MLS system has been identified by one administration but its deployment in other countries is not known at the present time.

There are plans in at least one administration and in ICAO for wind shear radar, automatic dependant surveillance air/ground data link and DGNSS ground/air data link, but sharing criteria are not yet developed.

Administrations should consider the continuing need for Aeronautical Mobile-Satellite (R) Service, Fixed-Satellite Service and Inter-Satellite Service, and the possibility of sharing it with Non-GSO/MSS feeder links.

Sharing with RDSS feeder links in the band 5150-5216 MHz is similar to the sharing with Non-GSO/MSS feeder links (case of NGSO/RDSS system) or GSO FSS (case of GSO/RDSS system).

It has been concluded that sharing between NGSO MSS feeder links and HIPERLANs is feasible in the uplink direction provided feeder link earth stations are

separated on the order of 3 to 10 km from indoor HIPERLANs and 16 to 50 km for outdoor HIPERLANs (which are expected to be only 1% of the total usage). These distances can be further reduced by taking into account local shielding. In the downlink, the interference level from a single NGSO MSS satellite is at least 25 dB lower than the maximum permissible level of -101 dBm. Since HIPERLAN systems are likely to be unlicensed, HIPERLAN users may be advised of any appropriate siting considerations in order to minimize the risk of interference.

4.5 Frequency Sharing Between Multiple NGSO MSS Feeder Link Networks

Studies to date have shown that sharing between two NGSO MSS feeder links is feasible. However, conclusions pertaining to more than two NGSO MSS systems sharing the same feeder link frequencies have not been agreed internationally. The results of these types of studies are critical in determining the total spectrum requirements for multiple NGSO MSS feeder links.

4.5.1 Summary of Results from Recent Analyses and Computer Simulations

In the U.S. three analyses and computer simulations have been conducted recently to determine the upper bound to the interference statistics resulting from "in-line" or main beam coupling between the feeder links of a NGSO MSS reference system and those of one or more other NGSO MSS systems operating their feeder links co-directionally in the same frequency band as the reference system. Although, the approach and methodology in each of the referenced analyses are similar, they are not identical. Nevertheless, all three analyses reach the same conclusion that at least three NGSO MSS feeder link systems can successfully share the same spectrum without significant adverse operational impact. Furthermore, each of the papers have shown that there are mitigation techniques or options available to the MSS operators to reduce the frequency of occurrence and duration of interference events.

4.5.2 Summary of Mitigation Techniques

For two or three NGSO MSS systems interfering into a reference NGSO MSS feeder link system, the total interference time (depending on the reference system) is on the order of 5000 to 6000 seconds or 0.02% of the time. By way of comparison, total yearly sun transit outage time for GSO systems is on the order of 7000 seconds.

All analyses to date indicate that total interference time, relative to any set of reference feeder links, is simply the sum of the (single-entry) interferences from each of the individual feeder links. Thus, if multiple NGSO MSS systems share common spectrum co-directionally, and fail to apply appropriate mitigation techniques (identified below), the total interference time can be expected to be on the order of the sun transit outage time for GSO systems, or possibly a small multiple of this time. This is potentially acceptable however, straightforward mitigation techniques exist which can dramatically reduce the total interference time as well as the impact of the interference. Ten such techniques are identified in Table 1 below.

TABLE I

List of mitigation techniques to reduce frequency and duration of interference events		
Technique	Explanation	Penalties/Shortcomings
1) Bigger gateway Antennas	Bigger antennas mean smaller beamwidth which reduces the chances of main beam coupling	More expensive antenna. Possibly more expensive pedestal. Some potential offset due to reduction in HPA power, reduced self-noise.
2) Beam steering	Steer gateway antenna boresight away from interfering or victim spacecraft by small fraction of a beamwidth	Reduction in desired carrier power, C.
3) Satellite diversity	Using a second satellite when the first is experiencing an interference event	Requires second satellite in view. Reduces degree of diversity available to mitigate other link impairments.
4) Gateway diversity	Using a second gateway when the first is experiencing an interference event	Requires second gateway in view. Reduces degree of diversity available to mitigate other link impairments.
5) Traffic Management (CDMA Systems)	Temporarily reduce traffic through "in-line" event to create link margin for excess RFI flux density from interfering system. Interference during periods of non-peak traffic may be tolerable without active mitigation	Potential impact on quality of service.
6) Outage tolerance	Designing systems that can tolerate outages lasting up to 20 seconds will minimize the impact of an interference event	Potential impact on design of gateway and user terminal (MES) hardware and software.
7) Gateway Location	Avoid latitudes that seem to maximize the chances of main beam coupling ($\sim 40^\circ$ N)	Potential requirement for additional gateways to compensate for avoidance of specific geographic bands.
8) Manoeuvring	Speeding up or slowing down a satellite to avoid a known or predicted interference event	Expenditure of station keeping fuel. Reduction in satellite lifetime or increased beginning-of-life bus weight (possible impact on payload).
9) Repeating ground tracks	Make ground track repeat times as small as possible	Potential impact on constellation management and spacecraft lifetime due to increased expenditure of station keeping fuel.
10) Nulling	Active adaptive nulling within the main beam can eliminate interference except for a small region on boresight	More expensive gateway antenna subsystem.

A substantial range exists relative to the potential reduction in interference time achievable through known mitigation techniques. First of all, it is important to emphasize

that the operational interference time is less than the geometric interference time due to traffic loading statistics and inherent margin in the system. Furthermore, when diversity is available, interference on a single satellite may exist but be operationally insignificant. Operationally significant interference time can probably be reduced by a factor of 10 or more if all mitigation techniques described above are considered in aggregate. Thus, even under worst case conditions and for worst-case pairings of NGSO MSS systems, operationally significant interference time can be held to a fraction of the sun transit outage time experienced by GSO systems.

It is not necessary for all NGSO MSS systems to implement all mitigation techniques. Indeed it appears that each MSS operator has a number of options which can be used independently without having to resort to extensive coordination with other MSS operators in order to share common feeder link spectrum. This sharing of feeder link spectrum will help to significantly reduce the feeder link spectrum requirements of the MSS.

5. Regulatory/Procedural Provisions for NGSO MSS Feeder Link Networks

5.1 Introduction

The regulatory provisions of Article 1 (RR-22) which allow the operation of the feeder links for other space radiocommunication services in the Fixed-Satellite Service, and certain regulatory provisions in Articles 8, 11 and 29, currently do not provide a commonly agreed interpretation for the accommodation of NGSO MSS feeder link networks. It is evident, based on the existence of conflicting interpretations of these elements of the Radio Regulations, and the fact that the BR does not apply RR 2613 in the examination of Appendix 3 notifications, that certain revisions are required.

There is a general recognition that both the GSO FSS satellite networks and Non-GSO/MSS feeder link networks must have a regulatory base which permits their orderly operation without any regulatory uncertainties to their full operational life.

This Section of the Report identifies some regulatory changes that could achieve this goal. Other Sections of this Report define the practical levels of co-channel, co-directional and bi-directional sharing that are operationally possible for these two

services. The regulatory changes described in this Section are, in part, based on these defined sharing opportunities.

5.2 Possible Regulatory/Procedural Revisions

5.2.1 General

The possible regulatory revisions could include the following:

- a) changes to Article 8 to identify qualifications for the use of certain frequency bands allocated to the FSS;
- b) in designated frequency bands, in order to establish equity, Article 11 and/or Resolution 46 to include NGSO MSS/Feeder Link networks in the same regulatory procedures that are currently applied to GSO FSS networks;
- c) any consequential changes to other regulations as appropriate.

5.2.2 Changes to Article 8

Some of the allocations to the Fixed Satellite Service could be qualified in a manner which will accommodate NGSO MSS feeder link networks. These qualifications in the Table of Frequency Allocations could be used to provide the type of frequency usage described in the sharing opportunities defined in this Report. In addition to these qualifications, for some of the current FSS allocations, there could be an additional allocation to the FSS in the reverse direction in the same frequency band.

The accommodation of the NGSO MSS feeder links spectrum requirements can be addressed differently in frequency ranges below and above 17.7 GHz.

5.2.2.1 Bands Below 17.7 GHz

Because of the difficulty of co-direction sharing of frequencies between Non-GSO/MSS feeder links and GSO FSS space networks, it is envisioned that below 17.7 GHz the NGSO MSS feeder link networks would use certain bands allocated to the FSS and would have a priority status over GSO FSS networks in a specific transmission direction. Regulatory provisions would be needed to make this usage by GSO FSS networks and NGSO MSS feeder link networks clear. Specific regulatory language would be needed to be developed in order to resolve any sharing difficulties when there are allocations of equal status in opposite directions.

In this regard, it has been assumed that, below 17.7 GHz, specific changes would be made by WRC-95 to Article 8 to accommodate the need to have certain priority for FSS allocations that would be used for NGSO MSS feeder links. In any FSS allocation to which this priority approach would not be applied, e.g. because it is heavily used by GSO FSS systems, RR 2613 would be maintained. The following provides a specific example of how such an approach could be implemented in the present Article 8. This approach should be reviewed and developed further by the CPM Procedures Working Party.

In this example, the use of bands allocated to the fixed satellite service by NGSO MSS feeder links on a primary basis is restricted to bands and direction of transmission specifically identified for such links. In other FSS bands, or in a transmission direction not identified for Non-GSO/MSS feeder links, the use of NGSO feeder links shall not cause unacceptable interference to or receive protection from GSO FSS networks. To accomplish this principle, WRC-95 could add a footnote to specific FSS bands that are to be used for Non-GSO feeder links as follows:

- the existing primary allocation to the FSS in the band of interest in the regular direction is kept as is;
- the band is allocated on a primary basis to FSS in the reverse direction, but this allocation is restricted to NGSO MSS feeder links;
- RR 2613 is waived in this band, but only for NGSO MSS feeder links in the reverse direction;

- Res. 46, suitably modified, applies in the band, between the GSO FSS networks in the existing FSS allocation and the NGSO MSS feeder links in the new FSS allocation, between the NGSO MSS feeder links in the new FSS allocation, and between the NGSO MSS feeder links in the new FSS allocation and the terrestrial services.

To take an example, if the band [xxx] is presently allocated on a primary basis to the FSS (Earth-to-space), the following additions would be made to Article 8 table of allocations:

- in the Table of Article 8, FSS (space-to-Earth) primary in the band [xxx], with a new footnote yyy;
- in a footnote yyy associated with this new allocation: "The use of the band [xxx] by the FSS (space-to-Earth) is limited to NGSO MSS feeder links. The provisions of RR 2613 do not apply for this FSS (space-to-Earth) allocation;
- an additional footnote zzz is inserted for both the current and the new FSS allocations: "The use of the band [xxx] by the FSS is subject to the application of the coordination and notification procedures set forth in Resolution 46 (suitably modified), for the coordination between GSO networks (Earth-to-space) and NGSO networks (space-to-Earth), between NGSO networks (space-to-Earth) and between Non-GSO networks (space-to-Earth) and terrestrial services."

This approach would imply that the present priorities between services in the current allocations would be kept unchanged: RR 2613 would still apply to NGSO FSS including Non-GSO/MSS feeder links in the Earth-to-space direction, for which Resolution 46 (suitably modified) would not be applied.

If the bands corresponding to the FSS Allotment Plan are considered by WRC-95 for a new allocation to the NGSO MSS feeder links, protection of the plan would need to be ensured by specific provisions.

5.2.2.2 Bands Above 17.7 GHz

In the FSS bands above 17.7 GHz, where co-directional sharing between NGSO MSS feeder links and GSO FSS networks appears feasible with certain constraints, the following two options were considered as possible ways to satisfy the NGSO MSS feeder links in specific frequency sub-bands.

In the first option, because these allocations are lightly used at present, some of these bands could be provided with a footnote which permits all of the above systems on an equal basis. Such a footnote would exempt NGSO MSS feeder links in the FSS allocation from the application of RR 2613, and would make reference to the use of a coordination procedure such as Resolution 46, or a modified version of Article 11. Thus, once a NGSO MSS Feeder Link system or a GSO FSS system has been coordinated, it would have full rights to protection from GSO FSS and NGSO MSS feeder link systems previously coordinated or subsequently proposed for operation in the same band.

It is recognized that in the bands above 17.7 GHz, while sharing is feasible with NGSO MSS feeder link networks having specific characteristics and specific operational capabilities, this type of sharing creates the existence of geographic exclusion zones around both the GSO FSS and NGSO MSS Feeder link earth stations which is considered constraining on both FSS applications. Co-directional sharing also requires the NGSO MSS feeder link network to take certain actions to reduce interference to and from GSO FSS networks. Under a co-primary sharing arrangement, if the GSO FSS usage continues to increase, eventually the NGSO MSS feeder link network will reach its limit in its ability to minimize interference to and from GSO FSS systems such that it could not accommodate any new GSO FSS networks. Thus identifying a certain sub-band in the 17.7-19.7 GHz and 27.5-29.5 GHz bands for use primarily by Non-GSO/MSS feeder

links may be a preferred option as it guarantees future access to all FSS applications.

This second option would therefore entail the following:

- RR 2613 would be waived in those sub-bands identified for use primarily by Non-GSO/MSS feeder link networks;
- accommodation of existing GSO FSS networks would be provided such that they would continue to have equal status with respect to NGSO MSS feeder link networks in those specific sub-bands;
- within these specific sub-bands, future GSO FSS networks would not cause harmful interference to, or receive protection from, NGSO MSS feeder link networks.

In addition to the above options, it is noted that when determining the FSS frequency allocations to be used for NGSO MSS feeder links, the CPM and the WRC-95 should take into account any NGSO MSS feeder link systems that are operational and notified in accordance with Articles 11 and 13.

5.2.3 Changes To Article 11 and/or Resolution 46

Revisions should be made to Article 11 and/or Resolution 46 so that all of the procedures currently applied to GSO Fixed-Satellite Service, particularly the coordination procedures of § II of Article 11, will also be applied to NGSO MSS feeder link networks in the appropriate frequency bands.

A thorough examination of Resolution 46 procedures shows that nothing in the current resolution precludes the coordination between NGSO MSS feeder links, between NGSO MSS feeder links and GSO FSS networks and between NGSO MSS feeder links and terrestrial stations from being undertaken, provided that:

- Article 8 clearly indicates the frequency bands in both directions of transmission, if required, either limited to NGSO MSS feeder links or shared on an equal basis by NGSO MSS feeder links and GSO FSS networks to which Resolution 46 would apply, and
- two paragraphs are added to the Annex to Res. 46 to respectively cover the case of coordination of a NGSO feeder link station with a GSO earth station operated in the opposite direction, and the case of coordination of a GSO

earth station with a NGSO feeder link station operated in the opposite direction.

These two additional paragraphs are required to take account of the coordination between two earth stations operating services in bands allocated with equal rights in opposite directions. These coordination procedures have to be dealt with by the two administrations on the territory of which the two earth stations potentially interfering with each other are located.

The transmit or receive coordination areas for the NGSO MSS feeder link earth station with respect to Fixed Service stations and FSS earth stations could be determined in accordance with Recommendations ITU-R IS.847 and IS.849, suitably updated to reflect WRC-95 allocations. In cases where the coordination area extends beyond the territory of the Administration planning the feeder link earth station, the agreement of those administrations which have territory within either the transmit or the receive coordination area for the station would be required.

The current § II to the Annex to Resolution 46 also covers implicitly the space-to-space coordination. For this particular case, it is possible to develop NGSO MSS satellite constellation PFD limits towards the GSO orbit in order to protect GSO FSS receivers.

5.2.4 Changes to Article 29

In the above regulatory/procedural provisions to accommodate NGSO MSS feeder links, the key factor in the use of the FSS frequency bands is the current provision RR 2613 and how the Bureau takes it into account in dealing with GSO FSS Networks, and NGSO feeder link networks.

While it may not be possible to find a single solution to the regulatory uncertainties addressed above, it is clear that provision RR 2613 by itself, whether modified or unchanged, will not be sufficient. Rather, it may be necessary, in addition to the specific allocation provision and footnotes discussed above, to modify for example RR 2613 itself and/or Articles 11 and 13 or Resolution 46 to make RR 2613 more effective; provisions giving specific instructions to the Bureau may be necessary. WRC-95 should decide the extent to which such additional changes are required in light of its decisions on the allocation issues above.

Further, for any allocations in RBW mode for use by NGSO MSS feeder links (space-to-Earth), there is a need to include PFD limits at the GSO from the NGSO MSS feeder link satellites.

6. U.S. Proposals for MSS Feeder Link Spectrum

Note that specific U.S. proposals for FSS bands to be allocated for MSS feeder link use are yet to be developed, in large part due to the fact that much of the U.S. MSS industry has been more recently focused on the international consideration of potential MSS feeder link bands (i.e. in the work of ITU-R TG 4/5). The most recent output from the ITU-R Task Group 4/5 meeting contains a table of potential FSS bands to be further considered for MSS feeder links by WRC-95. As this table was developed at an international meeting, its contents do carry with them a certain level of international acceptance, with the appropriate caveats and constraints.

As was highlighted in the introduction to this Interim Report, many participants in IWG-4 were also actively involved in the development of the TG 4/5 output documentation, including the final table, and hence IWG-4 endorses its contents. This table is included in the following pages and shall serve as the basis from which IWG-4 shall develop future proposals for MSS feeder link spectrum for WRC-95. Note that there are candidate MSS feeder link bands in each of the C, Ku and Ka-Bands. Also note that there are potential sharing constraints listed for various bands. IWG-4 intends to include discussion of these constraints, for each of the appropriate bands, in the final report of the IWG.

FSS Bands to be Further Considered by IWG-4 for NGSO MSS Feeder Link Proposals for WRC-95 (December 21, 1994)

Frequency band (GHz)	Bandwidth (MHz)	Transmission direction for FSS	Current primary allocations	Frequency sharing possibilities	
				Codirectional	Bidirectional
4.5-4.8	300	downlink	FSS FS MS	Sharing not feasible.	Sharing technically feasible given careful site selection and gateway station antenna sizing to accommodate systems operating in accordance with RR Appendix 30B. MSS Feeder links should use an appropriate provision Trans-horizon systems transmitting several kW would make sharing difficult in parts of this band. -155 dB(W/m ² /4 kHz) pfd limit needed to protect mobile receivers. MS transmitters would create high pfd at the satellites for < 1% of time.
5-5.25	250	Downlink or Uplink	FSS (797) RDSS (797A) ARNS	Sharing depends on nature of use under RR 797. Further study needed. Uplink sharing with MLS is technically feasible	Sharing depends on nature of use under RR 797. Further study needed. Downlink sharing with MLS is possible at appropriate pfd.
6.65-6.725	75	uplink	FSS MS	Sharing not feasible.	Sharing technically feasible given careful site selection and antenna sizing, and depending on the number of gateway stations. Sharing feasible but site selection difficult in parts of R3.
6.725-7.025	300	uplink	FSS MS	Sharing not feasible.	Sharing feasible given careful site selection and gateway antenna sizing to accommodate systems operating in accordance with RR Appendix 30B. MSS Feeder links should use an appropriate provision. Sharing difficult in parts of R3
7.025-7.075 (Note 1)	50	uplink	FSS MS	Sharing not feasible.	Sharing feasible. Sharing difficult in parts of R3.

Frequency band (GHz)	Bandwidth (MHz)	Transmission direction for FSS	Current primary allocations	Frequency sharing possibilities	
				Codirectional	Bidirectional
10.7-10.95	250	downlink	FSS MS	Sharing not feasible.	Sharing technically feasible given careful site selection and gateway antenna sizing to accommodate systems operating in accordance with RR Appendix 30B. MSS Feeder links should use an appropriate provision. Sharing difficult in parts of R3.
11.2-11.45	250	downlink	FSS MS	Sharing not feasible.	Sharing technically feasible given careful site selection and gateway antenna sizing to accommodate networks operating in accordance with RR Appendix 30B. MSS Feeder links should use an appropriate provision. Sharing difficult in parts of R3.
12.75-13.25	500	uplink	FSS MS	Sharing not feasible.	Sharing technically feasible given careful site selection and gateway antenna sizing. MSS Feeder links should use an appropriate provision. Sharing difficult in parts of R3.
13.75-14 (Note 2)	250	uplink	FSS Radioloc'n SRS/EESS (855B)	Sharing not feasible.	Sharing technically feasible but site selection likely to become difficult. A coordination requirement must not be placed on the Radiolocation service, and a satellite pfd limit at the Earth's surface of -162 dB(W/m ² /4 kHz) is needed to protect that service. Protection required for the remaining lifetime of existing data-relay systems.
15.4-15.7	300	uplink or downlink	FSS (797) ARNS	Sharing depends on the nature of use under RR 797. Further study needed.	Sharing depends on the nature of use under RR 797. Under study in SG 8 but no conclusion yet.
18.4-19.2	800	downlink	FSS EES (passive) SR (passive) FS, MS	Sharing feasible with certain constraints. Sharing feasible.	Sharing possible if paired with a lower band. Sharing likely to be difficult (18.6-18.8 GHz)

Frequency band (GHz)	Bandwidth (MHz)	Transmission direction for FSS	Current primary allocations	Frequency sharing possibilities	
				Codirectional	Bidirectional
19.2-19.7	500	downlink	FSS	Sharing feasible with certain constraints.	Sharing possible if paired with a lower band. Operational constraints make difficult.
			FS, MS	Sharing feasible.	
27.5-28.5	1100	uplink	FSS	Sharing feasible with certain constraints.	Operationally impracticable.
			FS, MS	Sharing feasible.	
28.5-29.5	1000	uplink	FSS	Sharing feasible with certain constraints.	Operationally impracticable.
			FS, MS	Sharing feasible.	

Note 1 - It is noted that one administration intended to use this band for feeder links to NGSO/RDSS/MSS networks, and that this operation was possible under the present provisions of the Radio Regulations, i.e. in the Earth-to-space direction and subject to RR 2613.

Note 2 - In this band it would not be practicable for Non-GSO/MSS feeder links to share frequencies with GSO FSS networks unless the geographical density of feeder link earth stations was low.

Note 3 - It should be noted that, for the candidate feeder link bands listed above, there may be specific uses of the bands which have not been fully considered in the general analysis conducted thus far by IWG-4 (e.g. GSO MSS Feeder Link use of the band 10.7-10.95 GHz). Further deliberations by IWG-4 on these specific cases may result in proposals for restricted use, or deletion, of specific bands from further consideration. This shall be one of the primary tasks in the future work of IWG-4.